

U.S. Application No.: 09/998,993
Attorney Docket No. NOVLP074

REMARKS

Claims 1-25 are pending in this application. Claims 1-3, 6 and 8 were rejected under 35 U.S.C. § 102(e) as allegedly anticipated by U.S. Patent No. 6,596,641 B1 ("Jost"). Claims 7, 9 and 10 were rejected under 35 U.S.C. § 103(a) as allegedly obvious over Jost in view of U.S. Patent No. 6,100,202 ("Lin"). These rejections are respectfully traversed, for reasons including those set forth in previous responses (which are hereby incorporated by reference). Applicants' attorney appreciates the indications that claims 11-25 are allowable.

Applicants' attorney greatly appreciated today's telephonic interview with the Examiner and his Primary Examiner. During this interview, an agreement was reached as to how claim 1 could be amended to more clearly distinguish the prior art relied upon. The amended claim 1 is submitted in this paper and the rejections of claim 1 have therefore been overcome. Corresponding amendments have been made to claims 2, 4 and 6. It is respectfully submitted that all claims are now in condition for allowance.

Responses to Claim Rejections

One of the important distinctions between the teaching of Jost and certain aspects of the claimed invention is that, *during deposition*, Jost avoids changing a ratio of the dopant precursor gas flow rate to the silicon-containing gas flow rate. In contrast, the present invention teaches (among other things) that it is beneficial to change this ratio during deposition, e.g., to compensate for an increasing wafer temperature. For example, the specification of the present invention notes the following:

As illustrated above in Figure 4, as the temperature of the wafer increases during the initial period 407 of the deposition, the amount of dopant incorporated into the silicon dioxide layer is reduced. To compensate for this reduction, the amount of dopant precursor gas introduced into the reaction chamber is increased during initial period 407.

(Specification at p. 5, ¶ 26.)

In the example described above, the ratio is changed in a series of increments (though the ratio could be changed in other ways, e.g., continuously):

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As shown in blocks 504 and 505 [of Figure 5], the amount of dopant precursor gas introduced into the chamber is increased in a series of N increments until the dopant/silicon ratio reaches the final value. The final value is the ratio that provides the desired dopant concentration in the bulk layer 109 at the final temperature. As shown in block 506, once the final value of the dopant/silicon ratio is reached, the deposition continues until the desired layer thickness is reached.

(Specification at p. 5, ¶ 26.)

Block 504 of Figure 5 notes that the dopant/silicon ratio is changed while deposition is continuing: "while continuing deposition, increase value of ratio D/S."

Accordingly, claim 1 has been amended to emphasize that the initial and final periods recited in claim 1 are *deposition* periods:

1. (Currently Amended) A method for depositing a doped silicon dioxide layer onto a wafer comprising:

introducing a dopant precursor gas having a dopant precursor gas flow rate and a silicon-containing gas having a silicon-containing gas flow rate into a plasma within a deposition chamber, wherein a ratio of the dopant precursor gas flow rate to the silicon-containing gas flow rate has an initial value;

increasing the ratio within the deposition chamber from the initial value to a final value during an initial deposition period while the dopant precursor gas and the silicon-containing precursor gas react in the plasma to form the doped silicon dioxide layer on the wafer; and

maintaining the ratio within the deposition chamber at the final value during a final deposition period.[[.]]

~~wherein during the initial deposition period and the final deposition period the dopant precursor gas and the silicon-containing precursor gas react in the plasma to form the doped silicon dioxide layer on the wafer.~~

Therefore, claim 1 recites increasing a ratio of dopant precursor gas flow rate to silicon-containing gas flow rate the ratio within the deposition chamber during an initial deposition period, during which time the dopant precursor gas and the silicon-containing precursor gas react in the plasma to form the doped silicon dioxide layer on the wafer.

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As understood, Jost does not teach increasing a ratio of a dopant precursor gas flow rate to a silicon-containing gas flow rate during an initial deposition period (or during *any* deposition period). On the contrary, Jost teaches that each layer is deposited by using a *constant* ratio of a dopant precursor gas flow rate to a silicon-containing gas flow rate during each deposition process. Changes in the ratio of the dopant precursor gas flow rate to the silicon-containing gas flow rate are only made outside the deposition chamber and when deposition is not occurring. For example, Jost states:

The flowing first and second vaporized precursors are thereby initially bypassed within combined flowpath 70 from entering chamber 60 for a period of time while substrate 10 is within deposition chamber 60. The preferred desire and effect is to achieve steady state flow at the desired deposition conditions of the first and second precursors within line 70 prior to flowing the same to deposition chamber 60. The period of time to achieve stabilization is typically less than 10 seconds. Preferably after achieving a steady state flow, the first and second vaporized precursors are directed within combined flowpath 70 to flow into chamber 60 with the substrate therein under conditions effective to chemical vapor deposit first dielectric layer 22 (FIG. 3) comprising the first dopant, in this example phosphorous, over substrate 10. Such can be accomplished by reversing the opened/closed relationship of lines 72/74 with valve 76.

(Jost at col. 5, lines 24-40 [referring to Fig. 7].)

Here, stream 67 is a silicon-containing gas (TEOS), stream 68 is a phosphorous precursor and stream 69 is a boron precursor. (See col. 4, lines 55-64 and annotated Figure 7, attached.) Therefore, stream 70 is a combination of dopant precursors and silicon-containing gas. Stream 80 is a mixture of O₂ and O₃. (See col. 4, lines 64-67.) Accordingly, when valve 76 is initially closed to line 72 and is initially opened to line 74, the combination of dopant precursors and silicon-containing gas does not enter the deposition chamber and therefore no deposition can occur. (See annotated Figure 7, attached.)

During these transitional times, the silicon-containing gas and the dopant precursor gas are not allowed to enter the deposition chamber; instead, only pure oxygen or an inert gas is allowed to enter the deposition chamber. The silicon-containing gas and the dopant precursor gas are directed to an exhaust line:

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At the conclusion of such processing, preferably any flow of ozone within layer 80 is ceased, and a pure oxygen or inert gas caused to flow therethrough. Further preferably, valve 76 is preferably totally closed to line 72 and valve 76 is preferably totally opened to line 74, once again causing flowing vaporized precursor from lines 67 and 68 into line 70, into line 74 and out exhaust line 84.

(Jost at col. 5, lines 61-67; see annotated Figure 7, attached.)

Prior to the next phase of deposition, Jost teaches that the ratio of the silicon-containing gas to the dopant precursor gas(es) may be changed *outside* the deposition chamber; no further deposition is allowed to occur until the ratio achieves a steady state:

The flowing third vaporized precursor in line 69 is combined with the flowing bypassed first and second vaporized precursors in combined flowpath 70, with the combined flowing first, second and third vaporized precursors therewithin being bypassed to exhaust 84 and thereby prevented from entering chamber 60 for a period of time while substrate 10 is within chamber 60. As with the above-described processing, such period of time is preferably suitable to achieve steady state flow of the combined precursors, and will typically be less than 10 seconds. During the time where deposition does not occur within chamber 60, the flow of gasses from line 80 is preferably again changed to be pure O₂ or an inert gas. In the preferred described embodiment, flows are preferably as described above, with an exemplary flow of the triethylborate in line 66 being at 100 mg/mm.

Preferably after the steady state has been achieved, the combined flowing first, second and third vaporized precursors within combined flowpath 70 are directed to flow into chamber 60 with substrate 10 therein under conditions effective to chemical vapor deposit a second dielectric layer 24 (FIG. 4) comprising the first and second dopants over first dielectric layer 22, and preferably directly thereon as shown.

(Jost at col. 6, lines 36-58; see annotated Figure 7, attached.)

Therefore, Jost does not teach changing the ratio of dopant precursor gas flow rate to a silicon-containing gas flow rate while deposition is occurring. Instead, Jost teaches that this condition should be avoided and that deposition should occur after such a ratio has reached a steady-state condition. In addition,

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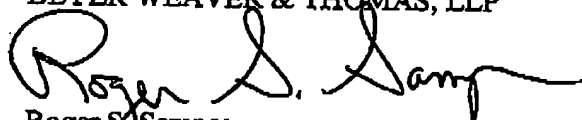
Jost does not teach changing the ratio of dopant precursor gas flow rate to a silicon-containing gas flow rate within the deposition chamber. Instead, this change occurs while the dopant precursor gas and the silicon-containing gas are being directed away from the deposition chamber to an exhaust line.

For all of the foregoing reasons, it is respectfully submitted that claim 1 is allowable over the art relied upon. Accordingly, claims 2-10 are allowable as dependent from claim 1.

Conclusion

Applicants' attorney thanks the Examiner and his Primary again for today's telephonic interview, during which time amendments to claim 1 were agreed upon that overcome the art relied upon. Claims 1-25 now define novel and non-obvious subject matter of the present invention. Therefore, a notification that the application is in condition for allowance is earnestly solicited. Please telephone Applicants' attorney if there are any remaining concerns that would prevent the issuance of a Notice of Allowance.

Respectfully submitted,
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